Voltage-Controlled Current Source Uses Two Op Amps

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One challenge in circuit design is building a good current source, especially when the load is variable or the current must be controlled with a voltage source. The **figure** shows a simple, low-cost voltage-controlled current source using two **op amps** that provides a good range of current and maximum load.

The idea is to apply a voltage on a reference resistor (or resistors) having a low thermal coefficient. The current passing through this resistor will be the output current. U1 adds the input voltage with V2, and U2 buffers the load voltage, so we have:

$V1 = V_{IN} + V2$

Obviously, U1's output current is amplified by Q1.

Applied voltage on the resistor network R is (V1 - V2), which will be equal to:

$V_R = V1 - V2$
$= (V_{IN} + V2) - V2$
$= V_{IN}$

So the output current will be:

$I_{OUT} = V_R/R = V_{IN}/R$

If R is a constant value (low thermal coefficient), the output current will be a linear function of the input voltage. Four resistors in series reduce the effect of thermal dependency.

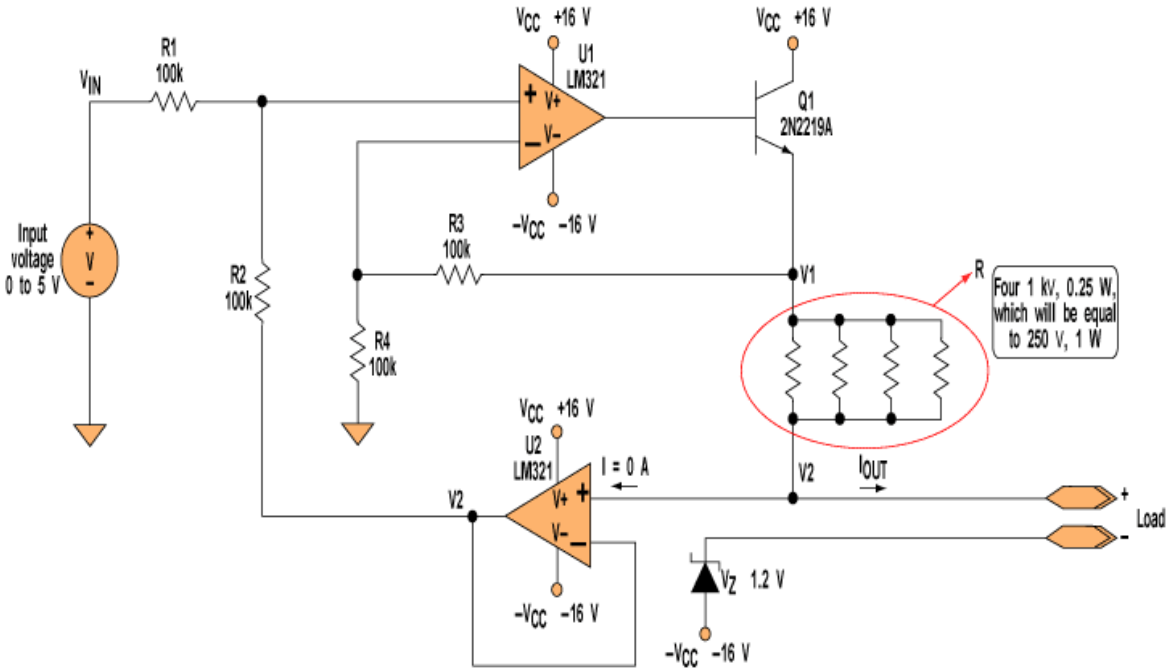
We also have to consider some other constraints. Limited supply voltages cause a limited maximum output current. And if the load is large, transistor Q1 must be able to handle the maximum current.

If U2 is a rail-to-rail amplifier, then the zener diode isn't required. Otherwise, it's needed to prohibit the current source from malfunctioning with low current outputs. (When V2 is very close to $-V_{CC}$, the buffer's output may not exactly follow input-voltage changes.)

Here is the calculation: Suppose we want to calculate the maximum output current with $\pm V_{CC}$, and R as the resistor value, when the input voltage has a maximum value of $V_{IN(MAX)}$. Then:

$I_{MAX} = [2 \times V_{CC} - (2 \times V_z) - V_{BE} - V_{IN(MAX)}]/R$

For the circuit shown, a maximum current of 20 mA is feasible for a maximum load of 1100 Ohms. Using higher-voltage op amps and larger power transistors can increase these values if cost isn't a concern.



To achieve a low thermal coefficient, the current-sense resistor (R) used by this voltage-controlled current source consists of four individual resistors in parallel.